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## NEW SPECIES AND RELATIONSHIPS IN THE GENUS *COLEOSPORIUM*

GEORGE G. HEDGCOCK, N. REX HUNT, AND GLENN G. HAHN

A study of the species of the form genus *Peridermium* occurring on the needles of pines in the United States, and of their relation to the various species of *Coleosporium* in the same range was begun by the senior writer in 1912. He has since been assisted in this work as follows: by William H. Long in 1914, by N. Rex Hunt from 1915 to 1918, and by Glenn G. Hahn in 1919 and 1920. All collections cited in this paper without the name of the collector were made by the senior writer; where made by others the name of the collector is given. This paper gives some of the results of the more critical sets of inoculations made with several species, chiefly during the past three years.

In the descriptions of fungi given in this paper, all measurements for averages are based upon either 50 or 100 individual measurements. Materials for study are prepared as follows: dried specimens are first placed in water, then heated to the boiling point, transferred to a 10 per cent. gum arabic solution for 15 minutes and sectioned with a freezing microtome. Sections are mounted in a solution of 30 per cent. glycerine in water tinged with erythrosin. Measurements of the sori of pycnia and aecia in length and width are taken chiefly from unsectioned dry material. Measurements of cell walls are the estimated median for the side walls of each cell and include wall papillae. The colors of pycnia, aeciospores, and peridia are based on fresh material.<sup>1</sup> As has already been pointed out (7),<sup>2</sup> the color in fresh pycnia furnishes a good diagnostic character. Pycnia when old fade, and although this feature loses in value with age, other characters still hold, such as arrangement on the leaves, and size.

<sup>1</sup> Colors used are those of R. Ridgway, Color Standards and Color Nomenclature, Washington, D. C., 1912.

<sup>2</sup> Numbers in parentheses refer to publications cited at the close of the paper.

All type specimens for the species described in this paper are deposited in the Pathological Collections of the United States Department of Agriculture, Washington, D. C. The numbers given with collections apply to collections for study in the Office of Investigations in Forest Pathology, Washington, D. C.

#### COLEOSPORIUM APOCYNACEUM

On March 27, 1918, near Silver Springs, Florida, a beautiful *Peridermium* with delicate fimbriate peridia was collected from the needles of *Pinus caribaea*,<sup>3</sup> *P. palustris*, and *P. taeda*, in direct association with plants of *Amsonia ciliata*<sup>4</sup> bearing the uredinia of *Coleosporium apocynaceum* Cooke, which were evidently from a recent infection. Inoculations were made April 3, 1918, by Hunt on six plants of *Amsonia ciliata* at Washington, D. C., in a greenhouse, with the aeciospores of the *Peridermium* from *Pinus taeda*. On April 15, the uredinia of *Coleosporium apocynaceum* Cooke appeared on the leaves of one plant, and later the telia, establishing that this *Peridermium* is the aecial stage of *Coleosporium apocynaceum* (10). Hedgcock repeated this inoculation on plants of *Amsonia ciliata* May 27, 1918, with aeciospores from a collection of the *Peridermium* from *Pinus palustris* at Silver Springs. May 7, 1918. Uredinia appeared on two plants June 9, and a month later telia were formed. Control plants in both these experiments remained free from the rust. Inoculations made with urediniospores on plants of *Amsonia ciliata* April 24 and May 24, 1918, resulted in the production of uredinia May 8 and June 9, respectively and of telia about a month later.

The aecial stage of *Coleosporium apocynaceum*, for convenience in distinguishing it from other species of the form genus *Peridermium*, is here named ***Peridermium apocynaceum*** (Cooke) Hedg. & Hunt, comb. nov., with the following description:

Pycnia, amphigenous, scattered, in one row on each side of the leaf, conspicuous, on chlorotic spots, dehiscent by a longitudinal slit, hazel-brown to chestnut-brown, 0.4–0.8 mm. wide, 0.6–1.4

<sup>3</sup> The name of forest trees used in this paper are those recognized by Geo.

B. Sudworth in various publications of the Forest Service, Washington, D. C.

<sup>4</sup> The names of herbaceous plants and of shrubs are those recognized by J. K. Small, *Flora Southeastern United States*, 1913.

mm. long, and 0.1–0.2 mm. high, averaging 0.5 by 0.85 by 0.16 mm.; pycnospores 2–3 by 4–7  $\mu$ , averaging 2.4 by 5  $\mu$ .

Aecia from a limited mycelium, amphigenous, one to several in a single row usually on the inner sides of the leaves, on chlorotic spots, occasionally confluent, flattened laterally, rectangular before rupturing, 0.26–0.5 mm. wide, 2–20 mm. long, and 0.25–0.45 mm. high, after rupture, averaging 0.35 by 6.1 by 0.35 mm.; peridium thin, rupturing circumscissally, the ruptured edges recurved and lacerated or irregularly fringed, fragile; peridial cells ellipsoid to cylindric, occasionally claviform, 18–33  $\mu$  wide, 25–63  $\mu$  long, averaging 23 by 42  $\mu$ , slightly overlapping but loosely adherent, with walls 2–6  $\mu$  thick, averaging 4.4  $\mu$ , outer walls thicker than inner, both verrucose with cylindric papillae 1–2  $\mu$  in diameter by 2–6  $\mu$  in length, averaging 1.3 by 3.8  $\mu$ ; aeciospores ovoid to ellipsoid, occasionally pyriform, 16–23 by 22–42  $\mu$ , averaging 19.1 by 31.5  $\mu$ , contents orange, fading when old, walls 3–6  $\mu$  thick, averaging 4.7  $\mu$ , verrucose with short, blunt tubercles 2–4  $\mu$  in diameter and 2–6  $\mu$  long, averaging 2.6 by 3.9  $\mu$ .

*Coleosporium apocynaceum* Cooke has been collected in the United States only as follows:

O. and I. On *Pinus* near Ocala, Florida:

*P. caribaea*, in 1918, March 27 (25212) and April 7 (29101).

*P. palustris*, in 1918, March 27 (25214, type collection), April 7 (29100); in 1919, February 27 (32141) and May 15 (32379).

*P. taeda*, in 1919, March 27 (25213) and May 15 (32384).

II and III. On *Amsonia*:

*A. amsoniae*, South Carolina, in 1860, by H. W. Ravenel, Pinopolis (*Fungi Caroliniani Exsiccati*, 489); Alabama, in 1864, by T. M. Peters (Peters Collection, University of Alabama); in 1896, by F. S. Earle and L. M. Underwood, Auburn, Alabama, July (*Flora Alabama*).

*A. ciliata*, South Carolina, in 1852, by H. W. Ravenel, Aiken (*Fungi Caroliniani Exsiccati* 44); in 1916, by G. G. Hedgcock, Clearwater, September 27 (24102); Florida, in 1918, Silver Springs, Ocala, March 27 (25215), May 7 (25299), May 24 (25284 & 29116); and in 1919, May 15 (32378).

#### COLEOSPORIUM LACINIARIAE

Arthur first described the uredinia and telia of *Coleosporium laciniariae* in 1907 (1), reporting it from specimens of *Laciniaria*

*graminifolia* from Auburn, Alabama. He also mentioned its occurrence on *L. chapmani* in Florida. Since 1907, the known range of this species of *Coleosporium* has been greatly extended and a number of additional hosts found (6).

*Peridermium fragile* Hedgc. and Hunt (7) was first recognized in Florida at Brooksville on the needles of *Pinus palustris*, March 11, 1915. Numerous inoculations were made by Hedgcock and Hunt during 1915, 1916 and 1917 with the aeciospores of this *Peridermium* on many plants of species of *Aster*, *Chrysopsis*, *Elephantopus*, *Euthamia*, *Laciniaria*, *Pharbitis*, *Solidago*, *Verbesina* and *Vernonia*, without results. The plants of *Laciniaria* used were in poor condition. In the autumn of 1916, the collection of *Coleosporium laciniariae* on plants in direct association with pine trees which earlier in the season were infected with *Peridermium fragile*, indicated that *Laciniaria* was the alternate host genus for this species of *Peridermium*. Good thrifty plants of *Laciniaria* were secured and kept in stock. On March 20, 1918, Hunt inoculated the leaves of several species of *Laciniaria* with the aeciospores of this *Peridermium* from *Pinus palustris* (25135) at Ocala, Fla., March 15, 1918. One plant of *Laciniaria graminifolia* was infected, uredinia appearing April 11, and telia later. On March 4, 1919, Hedgcock inoculated one plant of *Laciniaria* sp. with aeciospores collected from *Pinus palustris* at Ocala, Fla., February 27. On March 22, uredinia appeared on the leaves. Telia were noted June 5. In both experiments control plants remained free from the rust. This proves that *Peridermium fragile* Hedgc. and Hunt is the aecial stage of *Coleosporium laciniariae* Arthur.

*Coleosporium laciniariae* Arthur has been collected as follows, the data being taken from collections in this office.

O and I. On *Pinus*:

*P. palustris*, Florida, in 1915, Brooksville, March 11 (17426, type of *Peridermium fragile*), March 11 (17427), March 12 (17430); in 1916, March 17 (20780, 20781, 20786 and 20787); in 1918, March 17 (25163); in 1919, March 2 (32161 and 32162), March 3 (32172); May 15 (32465); Ocala, in 1916, March 16 (20775); in 1918, March 15 (25135); in 1919, February 28

(32153); in 1919, Gainesville, March 20 (20806); in 1919, Lake City, March 12 (32231); Georgia, in 1915, Waycross, April 1 (17594).

*P. rigida*, New Jersey, in 1916, Pleasantville, June 5 (22347); Mount Calvary, June 5 (22348); in 1917, Mount Calvary May 12 (26522); District of Columbia in 1917, Washington, May 31 (24522).

II and III. On *Lacinaria*:

*L. elegans*, Florida, in 1915, Ocala, October 27 (20073); Jacksonville, October 30 (20085).

*L. elegantula*, Alabama, in 1915, Auburn, October 7 (18895).

*L. gracilis*, Florida, in 1915, Lake City, October 25 (20057); Brooksville, October 28 (20077).

*L. graminifolia*, New Jersey, in 1915, Pleasantville, September 12 (17952); in 1916, Mount Calvary, September 2 (22762, 22763, 22764, 22765, 22766, 22767 and 22768); in 1917, September 18 (22620).

*L. laxa*, Florida, in 1915, Tampa, October 29 (20082).

*L. squarrolosa*, Arkansas, in 1915, Bald Knob, October 12 (18890); Tennessee, in 1916, Big Frog Mountain, September 21 (22864); Georgia, in 1916, Atlanta, September 24 (22958).

*L. tenuifolia*, Florida, in 1915, Lake City, October 25 (20058); Tampa, October 29 (20081); Jacksonville, October 30 (20086).

From these data, it will be seen that our known range of *Coleosporium laciniariae* is from New Jersey to Florida and Arkansas.

PERIDERMIIUM MINUTUM

*Peridermium minutum* Hedgc. and Hunt (7) is a small species of leaf *Peridermium* known only from Florida. It was first collected at Brooksville in 1915, and again in 1916 in the same locality and also at Gainesville. Repeated attempts without result were made in 1916 to infect plants with the aeciospores of this rust, using species of *Aster*, *Campanula*, *Calonyction*, *Coreopsis*, *Chrysopsis*, *Elephantopus*, *Helianthus*, *Ipomoea*, *Laciniaria*, *Parthenium*, *Pharbitis*, *Quamoclit*, *Silphium*, *Solidago*, *Verbesina* and *Vernonia*. On May 6, 1918, near Gainesville, Fla., the uredinia of a *Coleosporium* were found occurring abundantly on the leaves

of *Adelia ligustrina* under a tree of *Pinus glabra* heavily infected with *Peridermium minutum*. Healthy plants of *Adelia ligustrina* secured from another locality were packed in direct contact with fresh aecia of this *Peridermium*, mailed to Washington, D. C., and placed in pots. The uredinia of the *Coleosporium* appeared on these plants in about two weeks after they were potted, and later telia. On March 28, 1919, inoculations were made again in the greenhouse at Washington, D. C., on eight healthy plants of *Adelia ligustrina* with the aeciospores of the *Peridermium* collected on *Pinus glabra* at Gainesville, Fla., February 28, 1919. Uredinia of the *Coleosporium* appeared on the leaves of three plants April 14, and telia about June 1; six control plants remained free from the rust. This proves that it is the alternate stage of *Peridermium minutum* (10). This species of *Coleosporium* with minute sori differs from other known species of this genus, and is now given the name ***Coleosporium minutum*** Hedgec. and Hunt, comb. nov., with the following description:

Uredinia hypophyllous, numerous, small, scattered on slightly chlorotic areas on the leaves, circular to elliptic, 0.1–0.5 mm. in diameter, averaging 0.25 mm., orange-chrome, fading with age to white, ruptured epidermis inconspicuous; urediniospores sphaeroid to obovoid or ellipsoid, 15–23 by 18–31  $\mu$ , averaging 18.7 by 24.5  $\mu$ , walls irregularly thickened at the apex, 2–8  $\mu$  thick, averaging 4.9  $\mu$  verrucose with coarse conical tubercles, 2–4  $\mu$  in diameter, averaging 2.6–3.8  $\mu$ .

Telia hypophyllous, small, scattered or somewhat gregarious, rarely confluent, circular to elliptic in outline, 0.16–0.36 by 0.18–0.36 mm., averaging 0.22 by 0.26 mm., grenadine red, darkening with age; teliospores with wall swelling 20–36  $\mu$  above, averaging 24.2  $\mu$ ; contents orange-chrome, fading to almost colorless, cylindric to clavate or oblong, 18–32 by 30–70  $\mu$ , averaging 23.1 by 44.9  $\mu$ , rounded or obtuse at the apex, obtuse to narrowed below.

*Coleosporium minutum* Hedgec. and Hunt has been collected in the United States only and as follows:

O and I. On *Pinus*:

*P. glabra*, Florida, in 1916, Gainesville, March 14 (20737), March 15 (20768, type of *Peridermium minutum*), March 20 (20801); in 1918, March 13 (25126), March 28 (25223), May 6 (29118); in 1919, February 24 (32103) and March 12 (32230).

*P. taeda*, Florida, in 1915, Brookville, March 12 (17439); in 1916, March 17 (20782); in 1919, March 2 (32165), March 11 (32229).

II and III. On *Adelia*:

*A. ligustrina*, Florida, in 1918, Gainesville, May 6 (25298, type of *Coleosporium minutum*); in 1919, May 14 (32363, 32862); Brookville (32395); District of Columbia, in 1918, Washington, June 20 (29194).

#### COLEOSPORIUM ELEPHANTOPODIS

The successful inoculation of *Elephantopus* with *Peridermium carneum* Am. Auct. was first reported in 1917 (8), indicating the possible identity of *Coleosporium elephantopodis* (Schw.) Thüm. with *Coleosporium carneum* (Bosc) Jackson (*C. vernoniae* B. & C.). A careful study of these two species, however, has established the fact that they are not identical (10). The two are distinct in their host adaptation, in addition to slight differences in morphology. Even if these two species are not considered separate and distinct, they must at least be considered races of the same species. The writers choose to treat them as separate species, for reasons which follow:

Of 22 sets of inoculations made with *Peridermium carneum* in 1914, 8 infected plants of species of both *Elephantopus* and *Vernonia*, and 14 infected only those of *Vernonia*. Of 44 sets of inoculations made in 1915, 3 infected plants of species of both genera, 4 only those of *Elephantopus* and 37 only those of *Vernonia*. Of 28 sets of inoculations in 1916, 8 infected plants of species of both genera, 8 only those of *Elephantopus*, and 12 only those of *Vernonia*. In 1916 an effort, partially successful, was made to separate collections of *Peridermium carneum* by macroscopic characters into two lots, the one belonging to *Coleosporium elephantopodis*, the other to *Coleosporium carneum*. Later efforts have been quite successful.

From 1916 to 1919, 31 sets of inoculations have been made from aecial material adjudged to be the aecia of *Coleosporium carneum*; of these 24 infected only plants of species of *Vernonia*, 7 infected those of both *Vernonia* and *Elephantopus*, and none of



them, *Elephantopus* only. During the same period, 23 sets of inoculations have been made from aecial material adjudged to be the aecia of *Coleosporium elephantopodis*; of these, 17 infected only plants of species of *Elephantopus*, 6 infected plants of species of both *Elephantopus* and *Vernonia*, while in no case were those of *Vernonia* alone infected.

From 1916 to 1919, 10 sets of inoculations were made with aecial material grown in the greenhouse at Washington, D. C., by inoculating pines in incubation chambers with sporidia from the fresh telia of *Coleosporium elephantopodis*. In all of these sets, plants of species of *Elephantopus* were infected, those of *Vernonia* in each set remaining free from infection. During the same period, aecial material of *Coleosporium carneum* grown in the same manner was used in 4 sets of experiments with the result that only plants of species of *Vernonia* were infected, those of *Elephantopus* in each set remaining free from infection.

From 1914 to 1919, 7 sets of inoculations were made with the urediniospores of *Coleosporium elephantopodis* resulting in the infection only of plants of species of *Elephantopus*, those of *Vernonia* in each set remaining free from infection. During the same period 8 sets of inoculations were made with the urediniospores of *Coleosporium carneum*, resulting in the infection only of plants of species of *Vernonia*, those of *Elephantopus* in each set remaining free from infection. From the foregoing results we conclude that these two *Coleosporiums* are distinct species physiologically.

The *Peridermium* which infects plants of species of *Elephantopus* is very much less common than the one infecting plants of species of *Vernonia*. The former fungus has fewer, smaller, and lighter colored pycnia, which are ordinarily in shorter rows than those of the latter. The aecia of the former are more commonly somewhat triangular in side view, and usually slightly smaller. The peridial cells of the former usually do not overlap, while those of the latter are commonly overlapping. The aeciospores and urediniospores of the former are slightly smaller and more commonly globose and their cell walls are usually nearly uniform in thickness, while those of the latter are frequently distinctly thickened at the apex.

Upon the basis of the above physiological and morphological differences, the aecial form of *Coleosporium elephantopodis* (Schw.) Thüm. is designated **Peridermium elephantopodis** (Schw.) Hedgec. and Hahn, comb. nov. to distinguish it from other species of the form genus *Peridermium*, with the following description:

Pycnia amphigenous, solitary to several in one or two rows on chlorotic spots more commonly on the inner sides of the needles, dehiscent by a longitudinal slit, capucine-buff to orange-buff when immature, cadmium-orange to orange when sporulating, amber-brown to antique-brown at the time aecia are formed, 0.35–0.64 mm. wide, 0.36–1.06 mm. long, 0.08–0.2 mm. high, averaging 0.42 by 0.75 by 0.12 mm.; pycnospores, ovoid to ellipsoid 2–4 by 4–6  $\mu$ , averaging 2.3 by 4.1  $\mu$ .

Aecia amphigenous, solitary to few in one or two short rows, more commonly on the inner sides of the needles, flattened laterally, irregularly triangular to rectangular in side view, 0.3–0.9 mm. wide, 1.1–7.9 mm. long, 1.0–3.6 mm. high, averaging 0.7 by 3.5, by 2.3 mm.; peridia often vertically striated, orange-pink when fresh, rupturing longitudinally at the apex with irregularly notched edges; peridial cells in one layer, slightly or not overlapping, rectangular in cross section 20–40 by 32–72  $\mu$ , averaging 32 by 47  $\mu$ , with thick walls, 6–12  $\mu$  in diameter, averaging 8.5  $\mu$ , walls commonly verrucose, the inner with thickly set papillae 1–2  $\mu$  in diameter, 3–6  $\mu$  long, averaging 1.5 by 4.3  $\mu$ , aeciospores globoid to obovoid, or ellipsoid, capucine-orange in mass 14–24 by 20–32  $\mu$ , averaging 19 by 26  $\mu$ , with walls slightly or not at all thickened at the apex, 3–6  $\mu$  thick, averaging 4.2  $\mu$ , the outer surface closely verrucose with tubercles 1–2  $\mu$  in diameter, 2–4  $\mu$  long, averaging 1.4 by 2.6  $\mu$ .

The foregoing description is based on aecia from *Pinus caribaea* (20818) grown under controlled conditions in the greenhouse at Washington, D. C., from inoculations with sporidia from the telia of *Coleosporium elephantopodis* from *Elephantopus carolinianus*.

*Coleosporium elephantopodis* (Schw.) Thüm. has been found in the United States as follows, the data being taken from collections made by members of this office, chiefly by the senior writer.

O and I. On *Pinus*:

*P. canariensis*; District of Columbia.\*<sup>5</sup>

*P. caribaea*; District of Columbia\* and Florida.

*P. contorta*; District of Columbia.\*

*P. coulteri*; District of Columbia.\*

*P. echinata*; Alabama, District of Columbia\* and Georgia.

*P. mayriana*; District of Columbia.\*

*P. palustris*; Alabama, District of Columbia,\* Florida, Mississippi, North Carolina and South Carolina.

*P. radiata*; District of Columbia.\*

*P. rigida*; District of Columbia and North Carolina.

*P. serotina*; Florida.

*P. taeda*; Alabama, District of Columbia,\* Florida, Georgia, Mississippi, North Carolina, South Carolina and Texas.

II and III. On *Elephantopus*:

*E. carolinianus*; Alabama, Arkansas, District of Columbia,\* Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, Virginia, and Texas.

*E. elatus*; District of Columbia,\* Georgia and Mississippi.

*E. nudatus*; Florida.

*E. tomentosus*; District of Columbia,\* Florida, Mississippi, North Carolina, South Carolina and Tennessee.

#### COLEOSPORIUM CARNEUM

*Peridermium carneum* (Bosc) Seym. & Earle, the aecial form of *Coleosporium carneum* (Bosc) Jackson (9) was first described and illustrated by Bosc (5) in 1811 from a specimen on *Pinus palustris* from South Carolina. The description is meager and might apply to most any species of *Peridermium* on the needles of pine from South Carolina. The illustration, however, which Bosc gives is that of the form of *Peridermium carneum* found to infect species of *Vernonia* in our inoculations. Arthur in 1910 (2) first proved that *Peridermium carneum* belongs to *Coleosporium carneum* on species of *Vernonia*.

In order to set apart the aecial form of *Coleosporium carneum* from that of *Coleosporium elephantopodis*, the following descrip-

<sup>5</sup> Hosts or collections obtained from artificial inoculations in the greenhouse at Washington, D. C., are indicated here and later by an asterisk (\*).

tion is given of *Peridermium carneum* made from aecia on *Pinus caribaea* (25282) grown under similar and controlled conditions in the greenhouse at Washington, D. C., from inoculations with sporidia from the telia of *Coleosporium vernoniae* from *Vernonia noveboracensis*.

Pycnia amphigenous, solitary to several, in a single extended row on each side of the needles chiefly the inner, on distinctly yellowed-chlorotic spots, salmon-orange to orange-chrome before and at maturity, orange-rufous to auburn or chestnut after maturity, 0.1–0.2 mm. wide, 0.6–1.4 mm. long, 0.4–1 mm. high, averaging 0.13 by 0.57 by 0.92 mm.

Aecia amphigenous, solitary to several, extended in a single row chiefly on the inner sides of the needles, flattened laterally, usually irregularly rectangular or truncate, occasionally irregularly triangular in side view, 0.4–0.9 mm. wide, 1.5–8.4 mm. long, 1.8–4 mm. high, averaging 0.7 by 3.3 by 2.6 mm.; peridia sometimes vertically striate, rupturing longitudinally at the apex with irregular edges; peridial cells irregularly rhomboidal in cross section, usually considerably overlapping, 20–38 by 33–45  $\mu$ , averaging 27 by 29  $\mu$ , with thick walls 4–8  $\mu$  in diameter, averaging 5.2  $\mu$ , the inner walls, sometimes the outer, verrucose with dense papillae 1–2 by 3–5  $\mu$ , averaging 1.7 by 3.8  $\mu$ ; aeciospores, obovoid to ellipsoid, 16–25 by 25–38  $\mu$ , averaging 21.8–33.2  $\mu$ , with walls often thickened at the apex, walls 3–9  $\mu$  thick, averaging 6  $\mu$ , the outer surface verrucose with tubercles 2–3 by 2–7  $\mu$ , averaging 1.9 by 3.9  $\mu$ .

*Coleosporium carneum* (Bosc) Jackson has been found in the United States as follows, the data being taken from collections made by members of this office, chiefly by the senior writer:

O and I. On *Pinus*:

*P. caribaea*; District of Columbia,\* Florida.

*P. clausa*; Florida.

*P. coulteri*; District of Columbia.\*

*P. echinata*; Alabama, Arkansas, District of Columbia,\* Florida, Georgia, North Carolina, South Carolina, Tennessee, Texas and Virginia.

*P. glabra*; Florida.

*P. mayriana*; District of Columbia.\*

*P. nigra autriaca*; Ohio.

*P. nigra laricio*; Ohio.

*P. palustris*; Alabama, District of Columbia,\* Florida, Georgia, Louisiana, North Carolina and South Carolina.

*P. ponderosa* (*P. scopulorum*); District of Columbia, Ohio.

*P. rigida*; Connecticut, District of Columbia, Maryland, North Carolina, Ohio, Pennsylvania, Virginia and West Virginia.

*P. sabiniana*; District of Columbia.\*

*P. serotina*; District of Columbia,\* Florida, Georgia and South Carolina.

*P. taeda*; Alabama, Arkansas, District of Columbia,\* Florida, Georgia, Mississippi, New Jersey, North Carolina, South Carolina and Virginia.

II and III. On *Vernonia*:

*V. angustifolia*; Florida.

*V. baldwinii*; Arkansas, District of Columbia,\* Mississippi and Texas.

*V. blodgettii*; District of Columbia,\* Florida, North Carolina and South Carolina.

*V. drummondi*; Arkansas and Mississippi.

*V. flaccidifolia*; Alabama, District of Columbia,\* Florida, Georgia and South Carolina.

*V. gigantea*; Georgia, Mississippi, South Carolina and Tennessee.

*V. glauca*; District of Columbia,\* Louisiana and Maryland.

*V. interior*; Arkansas, District of Columbia\* and Texas.

*V. maxima*; Alabama, Georgia, Louisiana, Ohio and Tennessee.

*V. noveboracensis*; Alabama, Connecticut, District of Columbia,\* Georgia, Maryland, New Jersey, North Carolina, Pennsylvania, South Carolina, Tennessee, Virginia and West Virginia.

*V. oligantha*; District of Columbia,\* Florida and Louisiana.

*V. ovalifolia*; Alabama.

*V. texana*; Louisiana and Texas.

*V. tomentosa*; Georgia and Louisiana.

### ***Peridermium floridanum* sp. nov.**

A new leaf *Peridermium* was collected on *Pinus palustris* near Ocala, Florida, March 17, 1916, but with the aecia frayed and past mature. This rust was found again on the same trees,

March 15, 1918. Hunt made inoculations March 27, 1918, with the aeciospores from the latter collection on 2 plants of *Verbesina virginica* without result. Collections of the fungus in the same locality were made from different trees February 26 and 28, 1919, but no clues as to its alternate host were secured later in the year during the season for telia. This rust approaches *Peridermium acicolum* in its gross morphology but differs in the color and arrangement of the pycnia, and in the arrangement of the aecia on the leaves. It is here named **Peridermium floridanum** Hedgc. & Hahn, with the following description:

Pycnia amphigenous, several, usually in a single row on the inner surfaces of the needles, on chlorotic spots, subcuticular, dehiscent by a longitudinal slit, tawny to russet, 0.36–0.8 mm. wide, 0.5–1.5 mm. long, 1–3 mm. high, averaging 0.52 by 1.04 by 0.15 mm.

Aecia amphigenous, on chlorotic spots, usually in a single row on the inner surfaces of the needles, 0.48–0.68 mm. wide, 0.9–3.6 mm. long, 0.76–2.16 mm. high, averaging 0.58 by 1.8 by 1.42 mm.; peridia flattened laterally, rupturing longitudinally at the apex with irregularly notched edges, peridial cells usually not overlapping in one layer, occasionally two layers at the base; ovoid to ellipsoid or rhomboid, 17–32 by 32–78  $\mu$ , averaging 22 by 53  $\mu$ , with walls 4–8  $\mu$ , averaging 5.4  $\mu$ , the outer walls thicker, walls verrucose with crowded papillae 1–2  $\mu$  in diameter, 3–6  $\mu$  long, averaging 1 by 4.4  $\mu$  aeciospores obovoid to ellipsoid, 12–20 by 22–38  $\mu$ , averaging 17 by 29  $\mu$ , with walls 1–4  $\mu$  thick, averaging 3  $\mu$ , the outer surface verrucose with short tubercles, 1–3  $\mu$  in diameter by 1–4  $\mu$  long, averaging 1.5 by 2.6  $\mu$ .

This *Peridermium* has been collected only in Florida near Ocala on *Pinus palustris* as follows: in 1916, March 17 (specimens lost); in 1918, March 15 (25137); in 1919, February 26 (32129), February 28 (32150, type of species).

#### PERIDERMIMUM INTERMEDIUM

From 1914 to 1919, collections of *Peridermium intermedium* Am. Auct. from the needles of *Pinus echinata* were made from Alabama, Arkansas, Georgia, North Carolina, South Carolina, Tennessee and Texas. These were used in 18 sets of experiments in which there were inoculated 192 plants of species of

*Aster*, *Chrysopsis*, *Coreopsis*, *Elephantopus*, *Euthamia*, *Helianthus*, *Ipomoeae*, *Pharbitis*, *Solidago*, *Verbesina*, and *Vernonia* known to be susceptible to species of *Coleosporium*. In 9 of these experiments, plants of species of *Vernonia* only were infected; in one experiment, plants of species of both *Vernonia* and *Elephantopus*; and in 8 experiments there was no infection. Control plants in each experiment remained free from infection.

In our inoculations with sporidia from the telia of both *Coleosporium elephantopodis* and *Coleosporium carneum* trees of *Pinus echinata* were infected the following year, bearing aecia of the species used in inoculations, proving that this species of pine is a host for both species of *Coleosporium*.

Of 54 collection of *Peridermium intermedium* Am. Auct. on *Pinus echinata* collected by members of this office in Alabama, Arkansas, Florida, Georgia, Mississippi, North Carolina, South Carolina, Tennessee and Texas; nearly 40 apparently belong to *Peridermium carneum* and the remainder to *Peridermium elephantopodis*.

Arthur and Kern (3) in 1906 described *Peridermium intermedium* from specimens collected on the needles of *Pinus echinata* by C. H. Demetric at Perryville, Missouri. The description of the species agrees in part with that of *Peridermium carneum* and in part with that of *Peridermium elephantopodis* as given by us earlier in this paper based on specimens on *Pinus caribaea* grown from artificial cultures at Washington, D. C. It is not wise to assign the type collection of *Peridermium intermedium* at present to either of these species, since we have never had the opportunity to section and examine aecia of the type collection. We have, however, sectioned and examined part of the exsiccati which had previously been examined and assigned to *Peridermium intermedium* either by Arthur or by Kern, which we assign as follows: Collection by H. von Schrenk, Eureka Springs, Arkansas, May 23, 1906 (1101) belongs to *Coleosporium elephantopodis*; collections in North Carolina by H. von Schrenk (1099) and C. D. Howe (20718) and R. P. Dale, Okay, Arkansas (15353) belong to *Coleosporium carneum*. There is always the possibility that any older collection may have two species inter-

mixed, and since we sectioned different aecia from those studied by Arthur and Kern, we may have examined a different species. The following species of *Peridermium* are now known to occur on *Pinus echinata*, viz.: *P. acicolum*, *P. carneum*, *P. delicatulum*, *P. elephantopodis*, *P. inconspicuum*, *P. ipomeae*, and *P. terebinthinaceae*, and the occurrence of more than one of these species on the same tree has often been noted by the senior writer.

#### DATA ON THE PERIOD OF FRUITING IN FOLLICULOUS SPECIES OF PERIDERMIIUM ON PINE

The period for fruiting among folliculous species of *Peridermium* on pine based upon the results of a large number of observations and experiments in infections is as follows: Infections take place as soon as the telia are mature on the alternate host. This begins much earlier in Florida than farther north, since the aecia and telia both mature at least two months earlier in Florida than at Washington, D. C., and three months earlier than in the mountains of Pennsylvania and in regions farther north. Aecia are mature in Florida from February to April, and telia from the middle of May to July or even later, varying with the species. Around Washington, D. C., aecia are found from April to June and telia from July to September or later. Inoculations with telia made at Washington, D. C., in September and October produce mature pycnia in two or three months and mature aecia on the same areas adjacent to the pycnia four to five months after infection. As a rule, a second crop of either pycnia or aecia is not produced in artificial infections, but four instances of deferred fruiting, one with *Peridermium acicolum*, and three with *Peridermium carneum* have been noted, in which pycnia and aecia were formed the second year following the time of inoculation. In Florida, however, the senior writer has frequently observed both *Peridermium carneum* and *P. ipomoeae* on *Pinus palustris*, bearing a second crop of aecia on the margins of old infections which had borne aecia the previous year.

#### NEW HOSTS FOR SPECIES OF COLEOSPORIUM

The following aecial hosts for species of *Coleosporium* are reported in this paper for the first time on species of *Pinus*:



- C. carneum* on *P. mayriana*.\*
- C. delicatulum* on *P. coulteri*.\*
- C. elephantopodis* on *P. canariensis*,\* *P. contorta*,\* *coulteri*,\* *P. radiata*\* and *P. serotina*.\*
- C. inconspicuum* on *P. palustris* at Styx, near Columbia, South Carolina.

*C. ipomoeae* on *P. serotina* from Styx, South Carolina.

*C. solidaginis* on *P. coulteri*.\*

*C. terebinthinaceae* on *P. serotina*, Clearwater, South Carolina.

*Peridermium floridanum* on *P. palustris*, Ocala, Florida.

The following uredinial and telial hosts for species of *Coleosporium* are now reported for the first time in the United States:

*C. elephantopodis* on *Elephantopus elatus*, District of Columbia, Georgia and Mississippi.

*C. helianthiae* on *Helianthus tomentosus* and *H. tuberosus*, Virginia.

*C. ipomoeae* on *Pharbitis cathartica*, Florida.

*C. laciniariae* on *Laciniaria elegantula*, Alabama; on *L. gracilis*, Florida; on *L. laxa*, Florida; on *L. squarrulosa*, Arkansas, Georgia, and Tennessee; on *L. tenuifolia*, Florida.

*C. minutum* on *Adelia ligustrina*, District of Columbia\* and Florida.

*C. ribicola*, on *Grossularia cynosbati*, Wisconsin; on *G. inno-minata*\* and *G. reclinata*, District of Columbia.\*

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